for more than 30 minutes, and supplying a current for a predetermined length of time, then, the result of the measurement is that the impedance of the transdermal is about 1.8 kΩ on an AC signal of 10 kHz (calculated as Rp: 4 kΩ and Cp: 0.008 μF) and is about 0.36 kΩ on an AC signal of 100 kHz (calculated by assuming that Rp = 0.4 kΩ and Cp = 0.002μF). Rp, here, is a resistance component of an equivalent circuit of the skin impedance and Cp is a capacity component. Detection of the reactive current is to measure a current that flows through the impedance of the capacity for AC current.

While the time constant of a living organism for DC current is about 6 ms (calculated as Rp: 100 kΩ and Cp: 0.06 μF), when no load is connected to the apparatus, there is no capacity and therefore a time constant seen from the apparatus is uncertain. Thus, a discharging resistor of, for example, 100 kΩ to 1MΩ is used in the circuit to provide a time constant of 0 ms. Detection of residual voltage is to measure the difference in time constant between them.

When the device for iontophoresis uses a waveform such as an AC waveform, a rectangular waveform, a DC waveform to which a rectangular waveform is superimposed, or a DC waveform to which an AC waveform is superimposed, a current is stored into the capacity of the skin during the positive period of the time-varying component and discharged from the capacity during the negative period. A reactive current that flows through the skin is detected by thus repeatedly storing and discharging the current.

When an intermittent current is used, a charge (voltage) is stored in the capacity of the skin by conducting the output, and the charge remains in the capacity during the off-period of the output and causes a voltage so that a residual voltage is measured.

In order to know the conduction states for the iontophoresis apparatus, it is sufficient to measure either the reactive current or the residual voltage.

Moreover, a display function such as a light emitting diode (LED) or a buzzer and a function for adjusting or interrupting the output may be added to the device for iontophoresis according to the present invention, in order to indicate to the user when an abnormal condition is determined by detecting the reactive current or residual voltage.

FIG. 3 illustrates an example of a detecting circuit for output current to detect a reactive current resulting from the capacity of the skin. In this embodiment, the output waveform superimposed with frequency components is used. Referring to FIG. 3, reference numerals 7B and 8B denote a negative output terminal and a current-detecting fixed resistor, respectively. Reference numerals 9B, 10B, and 11B denote a circuit ground, a voltage comparator, and an output signal from the voltage comparator, respectively. Reference numerals 12, 13, and 14 denote a current-storing capacitor, a discharging fixed resistor, and an analog switch, respectively.

FIGS. 4(a)-(d) illustrate voltage waveforms or current

waveforms, respectively. When the output is a rectangular waveform 15 having a frequency of 10 kHz and a duty cycle of 50% as shown in FIG. 4(a), the current outputted from the negative output terminal 7B is converted into an output current waveform 16 as shown in FIG. 4(b) by the fixed resistor 8B. By an analog switch 14 in synchronism with the output, the output current waveform 16 is passed as only the positive current waveform 17 as shown in FIG. 4(c) to a capacitor 12 of the succeeding stage, and then an output current signal 18 as shown in FIG. 4(d) is produced by smoothing out the waveform.

The voltage comparator 10B compares the output current signal 18 indicative of the reactive current that flows through the skin or the mucous with a threshold level SL pre-adjusted to a voltage value corresponding to a lower limit of the reactive current, thereby determining whether a reactive current exists. When the output current signal 18 is higher than the threshold level SL, the voltage comparator 10B outputs an output signal 11B of "H" to indicate to a control circuit that a conduction state is normal. When the output current signal 18 is lower than the threshold level SL, the voltage comparator 10B outputs the output signal 11B of "L" to indicate to the control circuit that a conduction state is abnormal.

The threshold level can be set to a voltage value that corresponds to a reactive current in the range of 0.01 to 10 mA and more preferably 0.1 to 1 mA, so that the conduction state may be detected even at low voltages. In order to detect